Design Principles for Robust Opportunistic Communication

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Waterloo?

Where is that?
Home of:
Seagram
RIM/Blackberry
Maple
OpenText
ManuLife; SunLife
Outline

- The context for opportunistic communication
- Some opportunistic applications
- Requirements
- Architecture
- Techniques to achieve robustness
- Conclusions
1. Computing costs are plummeting

Processor costs have come down by six orders of magnitude in three decades

CMOS allows on-chip logic, memory, imaging and RF components

Devices will merge computing, audio, and video
  • Processor
  • RAM
  • Flash memory
  • Cell phone modem
  • Still camera
  • Video camera
  • MP3 player

*From www.icknowledge.com
2. Wireless networks are proliferating
3. Data Centers aggregate resources
Where will this lead?

- Ubiquitous mobile devices will communicate with resource-rich data centers over wireless and wireline networks.
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Assume

- … that any mobile node can opportunistically communicate with any other node, fixed or mobile
Application 1: Wireless P2P video

- Shoot
- Create metadata (‘tag’)
- Segment
- Flood ‘want’ and ‘have’ metadata
- Route data
- Re-assemble
- Enjoy!
Application 2: Drive through Internet

- Roadside WiFi APs can upload and download data
  - up to 50 MB at 110 kmph
- Upload pictures and videos
  - potholes
  - construction sites
- Download pictures and videos
  - real estate
Application 3: KioskNet
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Requirements

Assume applications are tolerant to both delay and delay variance

- Should not require human intervention
- Should recover from disconnections
- Should support bulk data transfer
- Should be low cost
- Should be legacy compatible
  - minimal change to clients and servers
  - no change to TCP or IP
Additional requirements

- Should minimize device power usage
- Should maximize use of communication opportunity
- Should support both single and multi-hop communication
- Should provide over-the-air security
What makes this hard?

- Disconnection is first class
  - what does routing mean on a temporal graph?
- Affects every layer of the protocol stack
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Overview
Architecture
Outline

- Context
- Some opportunistic applications
- Requirements
- Architecture
- Design principles for robustness
- Conclusions
Gaining robustness

- **MAC**
  - Avoid the fringe
  - Avoid performance coupling

- **Network**
  - Flooding-based routing
  - Priority for less-replicated data items
  - Death certificates

- **Transport**
  - Hop-by-hop TCP

- **Application**
  - Directories

- **Overall**
  - Use databases for volatile state
  - Route detection and dissemination
  - Choose simpler solutions
Avoid the fringe
Avoid performance coupling
Flooding-based routing
Priority for less-replicated data items
Death certificates
Hop by hop TCP

- TCP hop by hop instead of end-to-end
- Allows recovery from wireless errors
  - One socket’s worth of buffers may need retransmission
Directory-based API
Databases for volatile state

- State
  - Cached values in RAM
  - Persistent values in database

On reboot, restore cache from db
Route detection and dissemination

For scheduled services

- Each device keeps track of sequence of other devices visited and visited times
- Schedules are automatically computed
  - Deviations can be detected and debugged
Use simpler solutions

- Initial version used complex systems: DHT, HIBC, flat names
- Tried and tested solutions worked better!
  - DNS
  - PKI
  - Hierarchical names
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Summary

- Opportunistic communication allows new \textit{classes} of applications
- But affects every layer of the protocol stack
- We have developed general design principles for robust opportunistic communication
  - at different layers
  - overall
Thank you!

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